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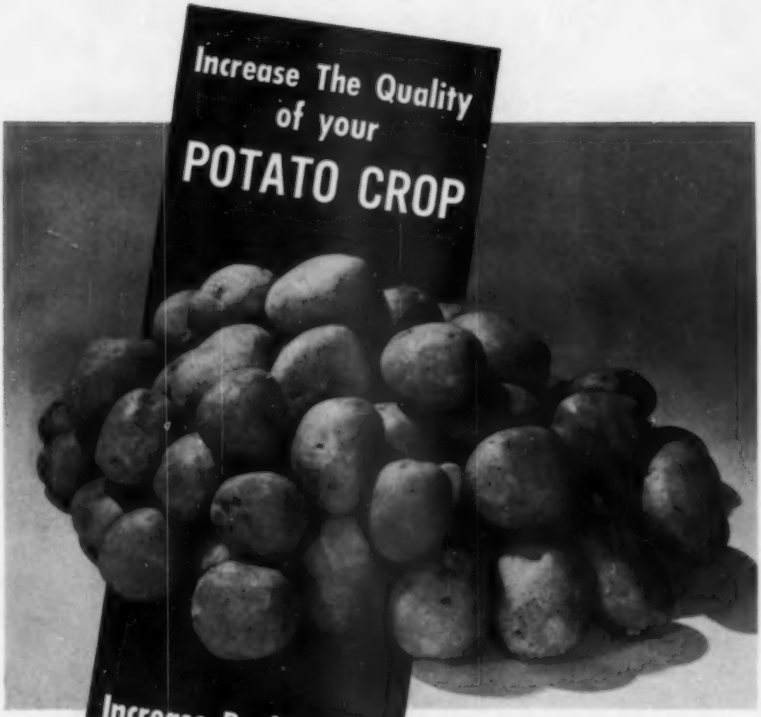

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A NECROTIC TYPE OF POTATO VIRUS Y[1]

M. KLINKOWSKI AND K. SCHMELZER[2]

In 1935 Smith and Dennis (28) isolated a virus from tobacco growing near potato plants. This virus was characterized by causing necrotic symptoms on tobacco. The authors suggested that it was a variant of potato virus Y, which was proven later. The virus was designated tobacco veinal necrosis virus (TVNV). Bawden and Kassanis (8) isolated this virus from South American potatoes and demonstrated the seriological relationship of TVNV with other strains of the virus Y, although there is no cross immunity. Tobacco inoculated with other known strains of virus Y reacts with veinbanding; these strains are now called "typical strains", "normal strains" or "old strains".

In 1944 Nobrega and Silberschmidt (19) reported on a virus causing necrosis of the secondary veins of tobacco, a disease they called "necrose das nervuras". There have been further reports on this virus, Orlando and Silberschmidt (20).

TVNV was also observed in Cambridge 1952 and 1953 in a wild potato of South America, Munro (18), quoted by Ross (23). This may possibly have been a subculture of the necrotic strains studied by other English authors.

In Germany TVNV was identified for the first time in 1951 in a potato sample from Emsland, Bode and Völk (10). In 1952 a tobacco disease, named "Tabak-Rippenbräune", was observed in Central Germany, Endemann (12), Klinkowski and Schmelzer (15). In the same year, a necrotic type strain was diagnosed in a tobacco sample from Ahlhorn in Oldenburg, Köhler (16); the occasionally used name "Y-Al" is derived from this place.

In Switzerland, the virus is supposed to have been first observed in 1953 on tobacco and potato plants, Bovey (11), Aubert (3). In other European countries, too, TVNV has been found. In Belgium resistant tobacco varieties have already been selected. Szirmai (29) identified the virus strain in Hungary on tobacco but according to a personal communication it has not yet been found there on potatoes. Ross (23) found TVNV in potato collections from Belgium, Holland, and Finland. Finally the reports of Kovachevsky (17) from Bulgaria are to be mentioned; he found virus Y several times in tobacco. Some of his isolates caused necrotic lesions and vein necrosis. The necrotic strain has probably spread into other European countries from which it has not yet been reported.

Our studies have shown that the several isolates from different countries are not identical. They differ considerably in physical characters. Although comparisons of symptoms do not provide a basis for exact statements, strains causing necrotic lesions only, without vein necrosis, as the one found by Silberschmidt, Rostom and Ulson (27), are not identical with the other strains, Schmelzer and Klinkowski (26). Without doubt, strains causing vein necrosis are closely related.

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In Germany and some other European countries, we now speak of strains of the Tabak-Rippenbräune-Virus (*Marmor upsilon* var. *costaenecans* Klinkowski and Schmelzer). We designate the strains belonging to this group as "new strains" or "necrotic strains" in contrast to the old or typical strains of virus Y.

Nicotiana tabacum var. Samsun is very useful for the differentiation of the two groups of strains of virus Y. The first symptoms of both groups are the same: vein clearing and a slight curving downward of the leaves (epinasty). Later, whitish or brownish necrotic lesions dispersed on the leaves developed in plants inoculated with necrotic strains. Sometimes the necroses follow the main veins (Fig. 1). The primary veins of leaves that are almost fully developed become brown. The leaves collapse prematurely against the stem, so that often only a little bunch of leaves remains at the top of the plant (Fig. 2). Also the stem shows necrosis, especially near its base (Fig. 3). The tobacco varieties Virgin Gold A, White Burley, and Ambalema react with similar symptoms.

The presence of different strains in Germany was reported by Bartels (7) as well as by Schmelzer and Klinkowski (25, 26). Bartels has found serological differences between strains. Our differentiation of strains was based on symptoms and reactions of the tobacco varieties Samsun and "V 20", as well as of the test plants *Solanum demissum*-hybrid "A 6", *Physalis floridana*, and *Petunia hybrida* (Fig. 4). The occurrence of different strains of TVNV creates a great difficulty in the breeding of resistant tobacco varieties. Several tobacco varieties, mainly cigar tobacco, are resistant to some strains of TVNV, however, lately these varieties have also been diseased. The virus isolates from these plants are infectious to all tested varieties of *Nicotiana tabacum*. Whether these recently isolated strains of TVNV are infectious to normally resistant varieties of potato remains to be tested.

Less virulent strains causing little or no necrosis on tobacco are known, too. Cross-immunity tests indicate their relationship to the new strains, Aubert (4), but it must be mentioned in this connection that the phenomena of cross immunity does not always occur between strains of tobacco veinal necrosis evidently closely related, Schmelzer, Bartels and Klinkowski (24). It may fail to occur even between typical strains, Richardson (21).

The necrotic strains cause the same range of symptoms on potato varieties as do the typical Y-strains. It extends from latency over mosaic and streak on the lower side of the leaves (Fig. 5) to leaf drop and premature death of the plant, depending upon the particular variety and whether the infection is primary or secondary. The symptoms in a variety infected by tobacco veinal necrosis strains are, however, usually milder than those caused by the old strains. It is clearly to be seen that in many varieties there exists a high tolerance of the tobacco veinal necrosis strains, since infection remains masked in their vegetative progenies. This frequently occurs even if distinct symptoms have been observed after primary infection. It is evident that hereby great difficulties arise for breeding as well as for certification. Diagnosis in the field, whether potato shoots are affected by the necrotic or the typical strains, is often impossible. In July and August, all varieties infected with the necrotic strains may show sporadic streak necroses along the veins. This symptom is called "late

FIG. 1.—Tobacco, var. Turkish, twelve days after inoculation with tobacco veinal necrosis virus strain "M 3". After Klinkowski and Schmelzer 1957.

FIG. 2.—Tobacco, var. Turkish, eight weeks after inoculation with tobacco veinal necrosis virus. After Klinkowski and Schmelzer 1957.

FIG. 3.—Stem necrosis on Turkish tobacco induced by tobacco veinal necrosis virus After Klinkowski and Schmelzer 1957.

FIG. 4.—*Petunia hybrida* two weeks after inoculation. Left: potato virus Y, normal strain "Y III", no local lesions. Middle: local lesions induced by tobacco veinal necrosis virus, strain "M 3". Right: systemic symptoms induced by the same virus. After Klinkowski and Schmelzer 1957.

FIG. 5.—Veinal necrosis on a potato leaf, a symptom of primary infection by a strain of tobacco veinal necrosis virus. After Arenz and Hunnius 1958.

streak" (Spätstrichel), Hamann (13). Variations in the growth habit are known too: the stems of affected plants tilt outward.

The serological test for the latent virus is possible, as Bartels (5, 6) found out, with the same exactness as for the virus X provided that leaves neither too old nor too young are used. Fully developed leaves in the top region of the shoot are especially suitable. Plants of secondary infection are fit for being tested in the fifth week after planting, when they are

12-15 cm (3-4 in.) high. In the spring, plants grown in the greenhouse may be tested in the fourth week, whereas during the winter, tests are possible only with six-weeks-old sprouts. Younger sprouts are not yet totally systemically infected, hence the results of the test may be uncertain. The margin of uncertainty of such serological tests is about 2 per cent, which is within the range of tolerance of other biological test methods.

The proportion in which old and new strains of the virus occur on potatoes in Germany is demonstrated by studies of Ross (23). In 1953, only typical strains of virus Y were found; in 1954, the proportion of necrotic to typical strains was 1 : 100; in the year 1955, this proportion had shifted to 1 : 6.2; in 1956 it was 1 : 0.8; and in 1957 both strain groups occurred in equal frequency.

In the last few years the epidemic spreading of virus Y in Germany has been observed. In North and West Germany, the frequency of potato virus Y considerably exceeds those of leaf roll and A viruses. Infections by virus Y are there nearly as frequently as infections by virus X. Ross (23) tried to determine whether this epidemic occurrence had been caused by necrotic strains only. He estimated the infection by virus Y to have been 15 times more frequent in 1958 than in 1953, when necrotic strains were practically unknown. In this calculation, varieties with more or less masked symptoms following infection with necrotic strains were not taken into account; however, the identification of old and new strains of virus Y did not result in a ratio of 1 : 15, but instead the ratio was 1 : 1.2. According to Ross, it is obvious that both strains participate equally in the epidemic spread. This is all the more astonishing since most of the infected sources are varieties with masked symptoms, nearly all of them being affected by the necrotic strains. For judging the connection between the facts, one should note that the spread of virus Y was much decreased during the year 1958, though the virus infestation was high. Hence one cause of its epidemic occurrence was the favorable conditions for transmission of both strain groups in earlier years. The virus Y epidemiology obtained its special note because of the necrotic type strains. It cannot be stated whether or not this strain group has been newly imported, since the detection of single occurrences is very difficult. For the spread of the necrotic strains it was essential that they succeeded in invading widely distributed varieties, where they exist in masked form. By this means, the infection sources have been distributed over the whole country, offering the vector insects a most favorable start for their general spreading of virus Y.

The easy transmission of TVNV by aphids was demonstrated by experiments of Bode and Völk (10). *Myzus persicae* became infectious after only 5 sec. of ingestion of the virus and transmitted it successfully during 10 sec. of feeding. Also the species *Doralis rhamni, Macrosiphon solanifolii, Doralis fabae, Acyrthosiphon onobrychis, Doralis frangulae,* and *Neomyzus circumflexus* were able to transmit the virus. Further, there exists the possibility of mechanical transmission. Beating healthy potato plants with diseased shoots resulted in 100 per cent infection, Witt (unpublished).

The statements of Ross about the epidemic spreading of the old and the new Y strains contradict the opinion of Richardson (21), who supposes that the necrotic strains do not become epidemic in those areas of potato

cultivation where typical strains are prevalent, since the latter—when mixed with necrotic strains—are preferentially transmitted by the aphids.

Studies by Arenz and Hunnius (1), Bode, Scheibe and Borchardt (9), and Hamann (13) demonstrated evident differences in the susceptibility of German potato varieties. Some resistant varieties reacted differently to the new than to the old strains.

In this connection, the possibility of preserving susceptible varieties in a healthy condition is worth mentioning. The requirements for this are to use seed potatoes free from virus trouble, isolation of growing areas from every supposed virus source, and the production of clear symptoms so that infected plants can be detected and eradicated. But a fast increase of infection rate is inevitable if symptoms in a variety tend to be masked.

In growing areas where potatoes are cultivated in the neighborhood of tobacco, valuable hints of any threatening infestation of this region may be obtained from data on the rate at which the tobacco becomes infected by the necrotic Y strains to which it is highly susceptible. A healthy plant always develops from tobacco seed. No reservoir of necrotic strains has been found in the European flora of weeds and wild plants. Therefore, if the tobacco shows veinal necrosis, potato plants affected by new strains of virus Y will be found in the nearer or wider environment. Special attention should be called to the fact that the tobacco is not a danger to potato culture; instead, it serves as an index of an existing infestation in potatoes or of a potential infestation.

Experiments of Arenz and Hunnius (1) have proved the date of harvest to be of considerable importance in affecting the symptoms of the tuber progenies. Tubers harvested at an early date and those harvested at the usual date produce shoots differing considerably in symptoms. Shoots of early-harvested tubers affected by the old strains generally show "ink spots" together with absolutely uncurled leaves typical of primary infection. Plants of the same variety produced from tubers harvested at the normal time exhibit a crinkle mosaic with only sporadic streaks. Early-harvested tubers contain a lower virus concentration than do later harvested ones. This difference in concentration not only affects the number of infected tubers per plant but also the number of infected sprouts as well. The new strains of virus Y, too, show clear differences depending on the date of harvest (Fig. 6). The effect of an early harvest is four times greater for the old strains of virus Y than for the necrotic strains. Only a few varieties, when infected with the old strains, are not influenced by an early harvest. As to the necrotic strains, the number of varieties showing no effect after early harvest is much higher. It is supposed that the new strains of virus Y move faster in the plant than do the old strains.

Let us now consider how the crops are influenced by infection by necrotic strains. We refer to experiments of Hamann and Goerlitz (14) as well as Arenz and Hunnius (2). Sprouting of infected tubers is not influenced by either old or new Y strains. With old strains, a tendency to accelerated sprouting may occasionally be observed. After infection with old strains, the plants die considerably earlier than do healthy ones. With the necrotic strains, the dying is evidently related to the severity of disease symptoms. Varieties with distinct disease symptoms die prematurely, whereas varieties with masked symptoms are scarcely influenced in their ripening. The number of tubers produced is reduced by infection

FIG. 6.—Potato plants of the same variety, grown from an early-lifted tuber (right) and from a normal-lifted tuber (left). The parent plants became infected at the same time by a strain of tobacco veinal necrosis virus. After Arenz and Hunnius 1958.

with the old strains at an average of 39 per cent with more than 30 varieties, however the mean reduction on account of the new strains amounts to only 12 to 14 per cent. Similar relations concerning yields were also found in the experiments of Arenz and Hunnius. With th old strains of virus Y, the the mean losses were 50.5 per cent (varying according to the particular variety from 6.6 to 84.7 per cent), whereas the losses due to the new strains were 13.8 per cent in crops of varieties masking the virus and 20.6 per cent in yields of varieties with marked symptoms.

In the future, seed potatoes should be produced chiefly in areas least infested by necrotic strains. Varieties with latent infections should be eliminated from the list of registration. More consideration should be given to breeding for resistance which does seem to have prospects. Ross (22) has found forms of *Solanum stoloniferum* with immunity from potato virus Y. In Germany, breeding work based on this character is under way.

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EFFECT OF COLOR AND INTENSITY OF FLUORESCENT LIGHTS AND APPLICATION OF CHEMICALS AND WAXES ON CHLOROPHYLL DEVELOPMENT OF WHITE ROSE POTATOES[1]

M. YAMAGUCHI, D. L. HUGHES, AND F. D. HOWARD[2]

After long exposure to fluorescent light, scrubbed White Rose potato tubers have been found to contain more chlorophyll than unscrubbed ones and greening was reduced by covering the potatoes with burlap to reduce light intensity (*2*).

Gull and Isenberg (1) studied the effects of light intensities, colored polyethylene bags, irradiation, and foliar sprays on chlorophyll formation in potato tubers. They found that greening at 25 foot-candles (ft-c) was less than that at 50 ft-c but at intensities above 50 ft-c no differences were observed. Potato tubers in red, yellow, blue and uncolored polyethylene bags exposed to 75 ft-c of fluorescent light for 60 hours contained about the same amount of chlorophyll as uncovered potatoes.

The data herein are from further investigations of chlorophyll formation in the White Rose tuber.

MATERIALS AND METHODS

The potatoes used in all experiments were California-grown U. S. No. 1 White Rose, scrubbed with commercial washing machinery in packing sheds in various production areas. The tubers were packed in light-proof boxes and immediately shipped to Davis, California, for studies.

The potatoes were exposed continuously to 40-watt cool white standard fluorescent lights unless otherwise indicated. Light intensity, in foot candles (ft-c), was measured with a General Electric Foot-Candle Meter.

To evaluate the effects of light quality on greening, the cool white lights were compared with General Electric 40-watt warm white deluxe, daylight, blue, green, gold, pink, and red fluorescent lights. In addition, light from four frosted 75-watt incandescent lamps was included. The experiment was conducted twice with different lots of tubers, and the results of the chlorophyll analyses are reported as per cent of the control.

Colored polyethylene films were supplied by several commercial fabricators of polyethylene bags. The light-transmission qualities of these and colored cellophane were compared by spectrophotometry. Their ability to retard tuber greening on exposure to light was also investigated.

Different light intensities were obtained by spirally wrapping a tape of aluminum foil around the fluorescent tubes. A stepwise platform was constructed to obtain different light intensities under any one set of lights. Two platforms were put in a constant-temperature room (70° F), with baffles so that the lights from one did not interfere with the other. The light intensities obtained ranged from 12 to 133 ft-c. Two replications of 15 tubers each were tested at each light intensity.

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[2]Associate Olericulturist, Laboratory Technician III, and Assistant Olericulturist, respectively.

Applied Chemicals

The formulations used, herein designated wax A and wax B, were obtained from commercial firms. After the tubers were immersed in cold water, the wax was applied with a small cellulose sponge dampened slightly with wax. Sufficient wax was applied so that a thin film remained on the surface. The tubers were allowed to air-dry before exposure to light. These waxing experiments lasted up to 96 hours of light exposure and even in this short period internal breakdown from anaerobic respiration was often observed. For this reason waxing does not appear to be an acceptable process.

Another lot was dipped in a solution of ethylene diamine tetraacetic acid (approximately 0.5 per cent EDTA). EDTA as foliar spray on potatoes has been found effective in reducing greening (1). Trans-cinnamic acid has been suggested as being effective in reducing greening. Tubers were dipped in a saturated solution of this chemical for 5 minutes and air-dried. A light absorbing chemical supplied by the Dow Chemical Company was tried in the search for another substance for reducing greening. Tubers were dipped in a 1 per cent solution of light absorber (Dibenzoyl-resorcinol) and in combinations with wax B and trans-cinnamic acid. Four replications of each of the treatments, 15 to 20 tubers per replication, were exposed to 90 ft-c of light for 48 hours and the tissue analyzed for chlorophyll content by the method below.

Chlorophyll Analysis

Tissue sampling for chlorophyll consisted of removing 10 to 15 cores from the exposed half of an indvidual tuber with a cork borer 1 cm in diameter. Discs about 3 mm thick were cut from the periderm side of the cores with an apparatus similar to one described by Larsen (3). The potatoes were sampled from both the apical and stem ends. It had been found that the opposite ends of the White Rose potato contain significantly different amounts of chlorophyll (2). Samples were taken from tissue free of eyes, and the discs were freeze-dried. The tissue was then ground in a Wiley Mill to pass through a 20-mesh screen. Chlorophyll was determined as previously described (2). The results were expressed as micrograms (μg) chlorophyll per 100 square cm area.

With scrubbed White Rose potatoes, a faint green is visually detectable at approximately 25μg of chlorophyll per 100 cm^2. Tubers are definitely green at 50 μg per 100 cm^2. Potatoes with 100 μg or more per 100 cm^2 are objectionably green, and may be considered unmarketable.

Results and Discussion

Quality and Intensity of Lights

Colored Fluorescent Lights: Since most of the newer supermarkets are illuminated with fluorescent lights, various colored fluorescent lights were used to study the effects of light quality. Chlorophyll content of tubers exposed to the different colored lights was compared to that under the cool white standard (Table 1). The blue, and daylight fluorescent light caused more greening than the cool white standard under 75 ft-c of light. Tubers under cool white deluxe had the same chlorophyll content as the control, but potatoes under warm white standard and deluxe, which have

TABLE 1.—*Effect of colored fluorescent light on chlorophyll formation in White Rose potatoes.*

Fluorescent lamp	Chlorophyll content (Per cent of control)	
	Expt. I[1]	Expt. II[2]
Control (cool white standard)	100	100
Cool white deluxe	100	104
Warm white standard	85	79
Warm white deluxe	80	82
Daylight	164	108
Blue	188	149
Green	23	56
Gold	33	37
Pink	121	84
Red	33[3]	13[4]
Frosted incandescent (75 watts)	46[5]	62[6]

[1]Expt. I.—75 ft-c and 72 hours illumination.
[2]Expt. II.—75 ft-c and 96 hours illumination.
[3]Red fluorescent, Expt. I.—32 ft-c.
[4]Red fluorescent, Expt. II.—60 ft-c.
[5]Incandescent, Expt. I.—80 ft-c.
[6]Incandescent, Expt. II.—75 ft-c.

less blue light, contained much less chlorophyll. Green, gold, and red fluorescent lights were most effective in reducing greening. Incandescent light, at approximately equal light intensities, produced less greening than did the cool white standard.

The appearance of the tubers under gold light was like that in daylight. Under cool white fluorescent light, the tubers appeared greener than when examined in daylight. Tubers under warm white fluorescent lights appeared normal.

Each series of experiments lasted four weeks since only two types of lights could be tested at any one time. Changes, if any, in greening ability of the potatoes under cool white standard were studied at the beginning, once at mid-point, and again at the end of the experiment. The greening rate of these potatoes stored at 68° F. did not change significantly during this period.

The results showed that, in general, tubers tended to respond to various wave lengths much as other plant tissue capable of synthesizing chlorophyll (4). Chlorophyll formation was most rapid under the blue, and much slower under green or gold fluorescent light.

Colored Polyethylene and Cellophane: Numerous samples of colored polyethylene films were tested in the search for material that would reduce greening. Table 2 compares the chlorophyll content of tubers under various colored polyethylene films with that of the control (no film). As found by Gull and Isenberg (1), clear and colored polyethylene films did not reduce chlorophyll formation enough to be of any practical value. Polyethylene films are generally somewhat opaque and the tubers cannot be seen easily. The reduction of greening under many of the polyethylene films probably was partially caused by the reduction in light intensity. The absorption spectra of the colored polyethylene were compared with

TABLE 2.—*Effect of various colored polyethylene films on chlorophyll development.*[1]

Colored Polyethylene	Intensity under film (ft-c)	Chlorophyll content (Per cent of control)
Control (no film)	75	
Yellow 1	67	100
Blue	58	86
Brown	54	81
Green 1	53	94
Red 1	48	78
Amber 1	46	93
Yellow 2	44	31
Red 2	43	88
Amber 2	40	71
Amber 3	41	73
Aluminum	37	54
Green 2	36	46
Amber 4	35	60
Turquoise	35	70
White	35	80
Red 3	13	62
Black	1	12

[1]Tubers exposed under cool white standard fluorescent light at 75 ft-c for 72 hours.

the chlorophyll formation spectra given by Smith (4). In practically all the polyethylene films tested, light absorption was low in the region where chlorophyll formation takes place.

The spectrum light incident on the potatoes from the cool white fluorescent light was changed by colored cellophane filters (Table 3). The yellows, tango (amber), and green-colored cellophane were very effective in reducing the chlorophyll content of the tubers. The low reduction was greater than can be accounted for by the reduction in light intensity. Light intensity was reduced greatly by the blue and violet cellophane, but the transmitted light caused appreciable greening. Larsen, on the other hand, found, with natural light at 50 ft-c and exposure of 34 days, that tubers under blue or green cellophane contained less chlorophyll than those under red or yellow cellophane.

TABLE 3.—*Effect of colored cellophane film used as filters on chlorophyll formation.*[1]

Color film	Light intensity under film (ft-c)	µg chlorophyll per 100 cm²	Per cent of control
Clear (control)	80	70	--
Red	12	26	37
Yellow, light	74	36	52
Yellow, medium	62	29	41
Tango (amber)	60	30	43
Green	20	25	36
Blue, light	39	41	74
Blue, dark	5	26	37
Violet	52	62	90

[1]Exposed 115 hours under cool white standard fluorescent light at 80 ft-c.

Of the colored cellophanes used, tango seems the most promising, for the appearance of the tubers was normal. No satisfactory inexpensive method is available to fabricate cellophane into bags, as can be done with polyethylene. Cellophane can, however, be used as a light filter in a canopy between the light source and the tubers.

Light Intensity: Fig. 1 shows the effect of different light intensities on the greening of White Rose tubers after 96 hours of continuous exposure at 70° F. Chlorophyll development increased with increasing light intensity, but not proportionally, for the efficiency of light in causing greening was lower at the higher intensities used. This may be due to the rate of protochlorophyll formation or to a light-filtering effect from the chlorophyll already present. Gull and Isenberg (1) found no significant increase in chlorophyll content at intensities beyond 50 ft-c in tubers of the Kennebec, Cherokee, and Katahdin varieties. For the White Rose variety, chlorophyll formation is rather rapid in light intensities as low as 12 ft-c. The amount of chlorophyll formed varied with different lots of tubers. However, the curves obtained are similar to that shown in Fig. 1. In some experiments the production of chlorophyll in response to light intensity continued to increase at higher intensities than shown in Fig. 1.

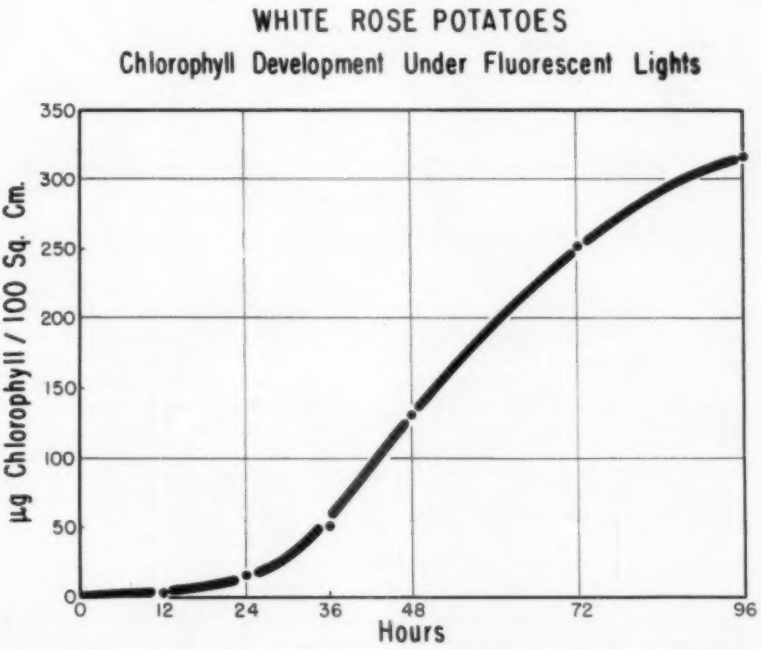

FIGURE 1.—The effect of 96 hours of light at different light intensities on chlorophyll content of White Rose potato tubers.

Rate of Chlorophyll Formation: Observations on the greening of freshly harvested tubers indicate a lag of 12 to 24 hours before greening is visible. Chlorophyll determinations confirmed this visual lag. Figure 2 shows that there was an actual lag period for nearly 12 hours before chlorophyll formation began. For this test, 100 ft-c at 70° C. was used. This response was observed in several different lots of tubers.

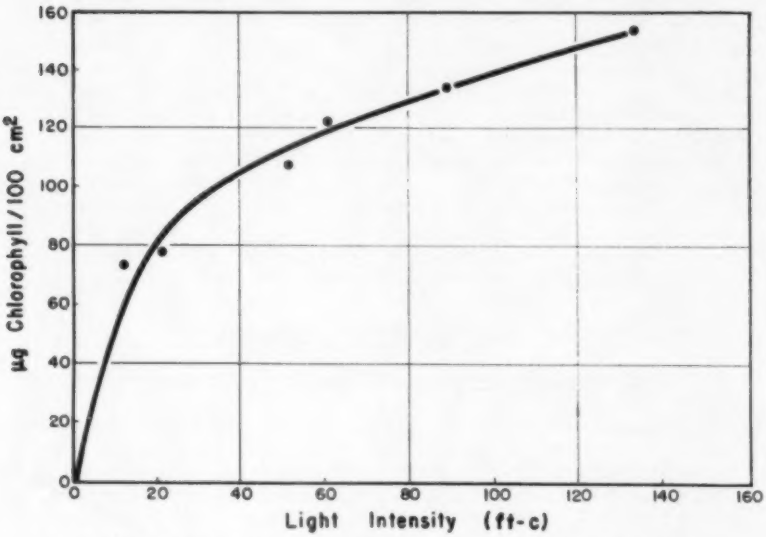

FIGURE 2.—Rate of chlorophyll development under 100 ft-c of light at 70° F.

Treatment of Tubers: Table 4 shows the effect of a chelating agent and two different waxes on chlorophyll formation. Wax B protected tubers more effectively than wax A. In both Experiments I and II, wax A was not effective in retarding greening after 48 or 96 hours of exposure to 90 ft-c. EDTA does not appear promising as an inhibitor of chlorophyll formation. Table 5 shows the effects of wax B, light absorber, trans-cinnamic acid, alone and in various combinations. Only waxing significantly reduced greening. Only with all three materials was the chlorophyll content significantly lower than with wax B alone. In one test, tubers from plants sprayed with maleic hydrazide three weeks before harvest showed a significant increase in chlorophyll content over the control.

SUMMARY

Greening of California-grown White Rose potatoes was studied under various light conditions. Tests were made to study the effect of colored fluorescent lights, colored polyethylene bags, colored cellophane light filters, and applications of waxes, trans-cinnamic acid, EDTA, and a light absorber.

TABLE 4.—*Effect of types of waxes and EDTA on chlorophyll development.*[1]

Treatment	μg chlorophyll per 100 cm² (Mean of 4 replications)		
	Expt. I		Expt. II
	48 hours	96 hours	48 hours
Check	103	160	126
Wax A	79	130	119
Wax B	37	70	63
EDTA	97	173	129
EDTA + wetting agent	96	158	116
L.S.D. 5 per cent	17	35	11
1 per cent	23	49	16

[1]Under cool white standard fluorescent light at 90 ft-c.

TABLE 5.—*Effect of applications of wax, light absorber, and trans-cinnamic acid on chlorophyll development.*[1]

Treatment	Chlorophyll content (Mean of 4 replications) μg per 100 cm
Check	153
Wax B	57
Light absorber	137
Trans-cinnamic acid	148
Wax B + light absorber	51
Wax B + trans-cinnamic acid	51
Light absorber + trans-cinnamic acid	152
Wax B + light absorber + trans-cinnamic acid	30
L.S.D. 5 per cent	17
1 per cent	24

[1]Under cool white standard fluorescent light at 90 ft-c for 48 hours.

The 75-watt incandescent lamp and green, gold, red, and warm fluorescent lights retarded greening below that resulting from the cool white standard fluorescent light.

Colored polyethylene did not retard chlorophyll formation enough to be of practical value. Yellow, tango (amber), green, and red cellophane retarded greening significantly.

Of the substances applied, only one wax formulation significantly retarded greening, however internal breakdown caused by anaerobic respiration can become a serious problem after wax applications.

Chlorophyll formation increased with increasing light intensity.

Rate studies indicate that 12 to 24 hours were required before chlorophyll began to form and green color became visible.

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DETECTION OF LATENT STRAINS OF POTATO VIRUS X BY ULTRAVIOLET LIGHT[1]

ANIELA KOZLOWSKA[2]

Strains of potato virus X produce in tobacco leaves a characteristic fluorescence in ultraviolet light. This phenomenon is associated with the accumulation of scopoletine in the host tissues. (1, 2).

First of all it was necessary to determine whether uninfected tobacco leaves fluoresce in ultraviolet light. Healthy tobacco leaves cultivated in a glasshouse were examined periodically under ultraviolet light for a period of two or three months, starting when the young plants had only two small leaves. Immature tobacco leaves prior to senescence showed no fluorescence in ultraviolet light. Distinct fluorescence appeared in the veins, when the leaves began to turn yellowish and to die. This happened especially when the tobacco seedlings were under unfavorable conditions, for instance at low temperatures. Consequently it was important to use for observations only very young immature tobacco leaves. .

It is also important to raise the tobacco plants in sterilized soil. Tobacco plants grown in ordinary hotbed soil always showed fluorescence in ultraviolet light at places where the leaves and the stem touched the ground. In sterilized soil, this phenomenon also appears but only to a slight degree.

It was necessary to determine whether juices from healthy potatoes and from other plant species, when rubbed on young tobacco seedlings, cause by themselves the fluorescence phenomenon. Different parts of virus-free potato tubers and potato leaves were employed for such simulated inoculations. Fluorescence did not appear on tobacco leaves, and serological tests were also negative.

Many simulated inoculations were also made with different plant species, such as Potentilla, Fragaria, Syringa, Cucumis and Senecio. Fluorescence in tobacco leaves did not appear.

Finally, it was necessary to investigate, whether juice from potato plants with bacterial or fungous diseases produce the same fluorescence phenomenon as does virus X. Tobacco leaves rubbed with juice of tubers with bacteriosis displayed no fluorescence. The results of an experiment with *Phytophthora infestans* however, were different. The mycelium of *P. infestans* was rubbed on young tobacco leaves. After several days, the veins showed a weak but distinct fluorescence. It is evident that for inoculation it is necessary to use potatoes free from blight (3).

Potato virus X strains which produce visible symptoms on tobacco leaves.

In the case of potato virus X strains which produce visible symptoms on tobacco leaves, calculations based on the number of local lesions developing several days after inoculation has hitherto been one of the most frequently employed methods for the quantitative determination of

[1]Accepted for publication December 29, 1959. An invitational paper presented at the 43rd Annual Meeting of The Potato Association of America. University of New Brunswick, Fredericton, N. B., Canada, August 1959.

[2]School of Agriculture, Cracow, Poland.

virus X concentration in plant juices. In physiological experiments, especially those on the influence of inhibitors upon the development of virus X in leaves during the period of incubation, it is of fundamental importance to determine as early as possible whether or not infection occurred. In such cases, one of the indispensible methods is the inspection in ultraviolet light of tobacco leaves inoculated with virus X, The fact is that local lesions are observable in ultraviolet light, as bright shining rings, sooner than they are visible to the naked eye. On the fourth day, and occasionally on the third day after inoculation, local lesions are already detectable in ultraviolet light, whereas no trace of them is visible to the naked eye at that time (Fig. 1). On the fifth and sixth day after inoculation, an average of twice as many local lesions are visible in ultraviolet light as are visible to the naked eye (Fig. 2).

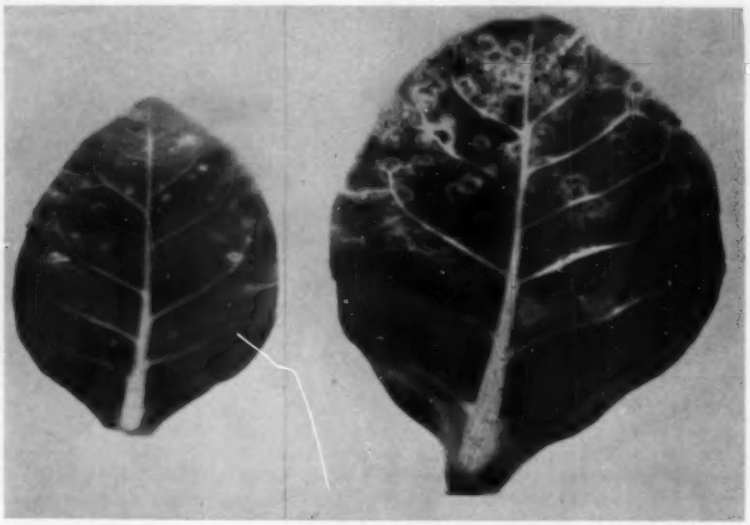

FIG. 1.—(Left) Tobacco leaf four days after inoculation with potato virus X strains showing local lesions in ultraviolet light.

FIG. 2.—(Right) Six days after inoculation.

Apart from shining rings, another phenomenon in ultraviolet light is the fluorescence of leaf veins on the under side of the leaves. In healthy tobacco leaves the veins show a bluish reflection in ultraviolet light, presumably this is caused by the nicotine content of the leaves. This reflection becomes progressively stronger as the leaf grows. When immature tobacco leaves, inoculated with virulent strains of virus X are examined in ultraviolet light, the veins shine with a white light, usually in interrupted segments. In leaves with systemic symptoms, fluorescence in segments both of the main veins and the lateral ones, is characteristic (Fig. 3).

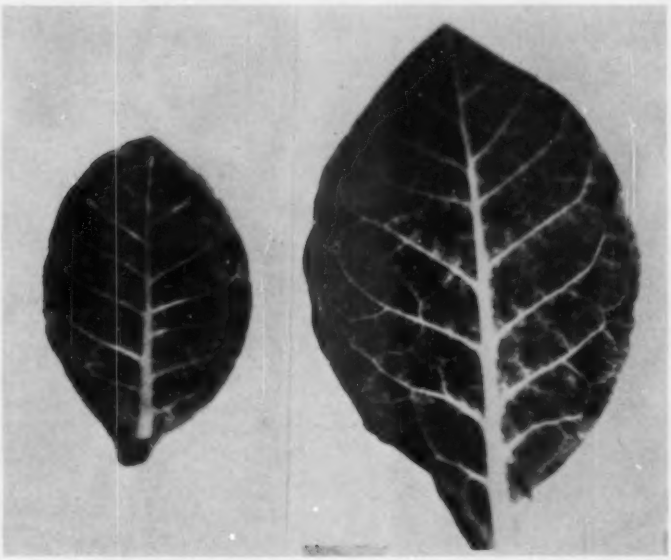

FIG. 3.—(Left) Tobacco leaf inoculated with virulent strain of virus X showing white fluorescence of both main and lateral veins under ultraviolet light.

FIG. 4.—(Right) Tobacco leaves infected with virus X plus virus Y showing strong fluorescence in main and lateral veins and a characteristic tortoise-shell structure between the veins in ultraviolet light.

Leaves that are infected with virus X plus virus Y display stronger fluorescence in their main and lateral veins than do singly infected ones. In addition a characteristic tortoise-shell structure is outlined between the veins (Fig. 4).

The phenomenon of fluorescence, in ultraviolet light, of tobacco leaves inoculated with virulent virus X strains is constant and it facilitates diagnosis and the isolation of different strains, Eiche and Bode (2), Kozlowska (3).

Virus X strains which produce no visible symptoms on tobacco leaves.

Immature tobacco leaves inoculated with latent strains of virus X, when inspected in ultraviolet light, demonstrate as a rule the same phenomena as do virulent strains but to a much milder degree. This pertains, first of all, to local lesions.

From the experimental station at Pentlandfield-Roslin, Scotland, the author obtained, in 1958, some potato tubers of the varieties Majestic and Dunbar Rover infected with a latent strain of virus X^{n}T8. The entire surface of immature tobacco leaves were dusted with carborundum powder and inoculated with this strain of virus X. Several days after inoculation small shining points between the veins were observable in

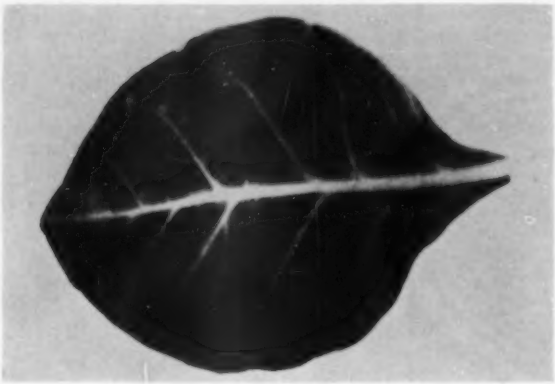

FIG. 5.—Tobacco leaf inoculated with a latent strain of virus X^{u}T showing small shining points between the veins and segmented fluorescence of veins in ultraviolet light.

ultraviolet light on some of the inoculated leaves. These fluorescent spots corresponding to the local lesions caused by virulent strains were not encountered in control leaves. Beginning from fifth day after inoculation, distinct segmental fluorescence of the main and lateral veins occurred in some leaves (Fig. 5). Unfortunately, the occurrence of such phenomena was not constant in the case of strain X^{u}, approximately 50 per cent of the inoculated leaves did not manifest the phenomenon of fluorescence although they contained serologically detectable virus. At low greenhouse temperature during autumn a higher percentage of the inoculated leaves showed fluorescence.

The latent strain of virus X maintained in our experimental potato fields in Crocow during the years 1948, 1949 and 1950, induced fluorescence of the main lateral veins in a much higher percentage of the inoculated tobacco leaves than did X. In the case of our latent strain, the characteristic bright fluorescence in segments of the main and lateral veins, indicating the presence of scopoletine, occurred on the third day and occasionally on the second day after inoculation. When a tobacco leaf was inoculated at one point, fluorescence in ultraviolet light was visible in the vein, beginning at the point of inoculation and spreading in subsequent days along the vein. This phenomenon never occurred when the leaves were rubbed with juice of healthy potato. Regardless of the frequent and distinct occurrence of fluorescence in tobacco leaves inoculated with our latent strain of virus X, the above mentioned phenomenon did not always accompany virus X infection, although virus X was serologically determined to be present in some tobacco leaves that showed no fluorescence in ultraviolet light.

SUMMARY

When immature tobacco leaves were inoculated with strains of virus X that induce local lesions, infected areas were detectable under ultraviolet

light 2 or 3 days before visible lesions appeared. They appeared as bluish fluorescent rings or spots. Later, segments of the veins also showed fluorescence.

Latent strains of virus X, when inoculated to immature tobacco leaves, also produced characteristic fluorescence in segments of the veins and occasionally feeble fluorescence at spots corresponding to local lesions. In contrast to virulent strains, the latent strain did not always induce ths phenomenon. Consequently, the absence of fluorescence cannot be considered to be proof of the absence of virus X in the leaf tissue.

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PROGRAM OF THE 44th ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

In Conjunction With

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

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August 29, 30, 31, 1960

AMERICAN BAPTIST ASSEMBLY
Green Lake, Wisconsin

Saturday, August 27, 1960 at 1:00 P.M. - *and* - Sunday Morning, August 28

Pre-meeting Tour of Research Plots*
Hancock Branch Experiment Station, Hancock, Wisconsin,
and Central Wisconsin Potato Area

Sunday, August 28, 1960 - *and* - Monday Morning, August 29, 1960

REGISTRATION

Monday Morning, August 29, 1960

Spurgeon Chapel, 9:00 A.M.

PAUL EASTMAN, *President,* Presiding

Business Meeting and Committee Reports

Pre-business meeting talk on "The Potato Industry in Venezuela" by Alvah L. Perry

Monday Noon, August 29, 1960

The Potato Association of America Recognition Luncheon

Crystal Room, Roger William Inn, 12:00 Noon

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*TOURS—A field tour of research plots and potato variety trials will start at 1:00 P.M. on Saturday afternoon, August 27, at the Hancock Branch Experimental Station, Hancock, Wisconsin, and will continue in the central Wisconsin potato area to visit several potato growing farms on Sunday morning, August 28, before going to the Assembly near Green Lake for registration. Plans have been made for the tour group to stay at Stevens Point, Wisconsin, over night, August 27.

The Hancock Branch Station is located on highway 51 about 80 miles north of Madison. For those wishing transportation to Hancock from Madison on Saturday morning, August 27, cars will leave the Horticulture building on the University campus at 10:00 A.M. Contact K. C. Berger, Department of Soils, University of Wisconsin, Madison 6, Wisconsin, for further information.

Monday Afternoon, August 29, 1960

"Potato Diseases" Joint Session with American Phytopathological Society

Rauschenbusch Hall Auditorium, 1:30 P. M.

A. P. BENSON, Presiding

1. **Host range, properties, varietal reaction and resistance in relation to isolates of potato virus F. (15 minutes).** G. F. KOLLMER, R. H. LARSON, University of Wisconsin, Madison, Wis.

2. **A new host for potato virus X in the *Leguminosae*. (15 minutes).** C. B. WILLIS and R. H. LARSON, University of Wisconsin, Madison, Wis.

3. **Carbohydrate reserves in grafted plants of Virus X resistant potato varieties. (15 minutes).** A. P. BENSON and W. J. HOOKER, North Dakota Agricultural College and Michigan State University, Fargo, N.D. and East Lansing, Mich.

4. **Transmission of spindle tuber and virus X in potatoes by cultivating equipment. (15 minutes).** F. E. MANZER, and DONALD MERRIAM, University of Maine, Orono, Me.

5. **The relation of eye position to the expression of leaf-roll virus symptoms in greenhouse-indexed potatoes. (15 minutes).** WILLIAM G. HOYMAN, Irrigation Experiment Station, Prosser, Wash.

6. **The influence of various fungicides and antibiotics on cut seed potatoes. (15 minutes).** A. E. RICH, C. S. CAMPBELL, P. T. BLOOD, R. E. MULLANY and F. E. MANZER. Eastern States Farmers Exchange, Springfield, Massachusetts; University of New Hampshire, Durham, N. H.; and University of Maine, Orono, Me.

7. **Urea formaldehyde concentrate-85 for scab control in potatoes. (15 minutes).** T. H. SCHULTZ, K. C. BERGER, H. M. DARLING and M. H. FLEISCHFRESSER. University of Wisconsin, Madison, Wis.

8. **The relation of soluble manganese to the incidence of common scab in potatoes. (15 minutes).** J. J. MORTVEDT, M. H. FLEISCHFRESSER, K. C. BERGER and H. M. DARLING. University of Wisconsin, Madison, Wis.

Tuesday Morning, August 30, 1960

Spurgeon Chapel, 9:00 A.M.

WALTER SPARKS, Presiding

1. **Effect of chloride and sulfate sources of fertilizer on potato growth and tuber quality in Southwestern Indiana. (15 minutes).** G. E. WILCOX, Purdue University, Lafayette, Ind.

2. **Influence of chlorides and sulfates in potato fertilizers on the phosphorus uptake, yield, and quality of potatoes. (15 minutes)** P. E. POTTERTON, K. C. BERGER, and E. L. HOBSON, University of Wisconsin, Madison, Wis.

3. **Methods of supplying nitrogen for potatoes. (15 minutes).** ARTHUR HAWKINS, University of Connecticut, Storrs, Conn.

4. **The influence of irrigation method, frequency and quantity of water application on the yield and quality of potato tubers and the nutritional status of the potato plant. (15 minutes).** JAY I. HADDOCK, U. S. Department of Agriculture, Logan, Utah.

5. **Storage and planting tests with precut seed potatoes. (15 minutes).** W. L. SMITH, JR. and R. V. AKELEY. U. S. Department of Agriculture, Beltsville, Md.

6. **Effects of irradiation on storage qualities of Russet Burbank potatoes. (10 minutes).** W. M. IRITANI, University of Idaho, Aberdeen, Idaho.

7. **The effect of ventilation rates on the keeping quality of stored potatoes. (10 minutes).** HARVEY TOKO, U. S. Department of Agriculture, Presque Isle, Me.

8. **Resistance to potato rot nematode. (7 minutes).** H. M. DARLING and R. V. AKELEY, University of Wisconsin, Madison, Wis., and United States Department of Agriculture, Beltsville, Md.

9. **A recessive type of immunity to virus X in the potato as evidenced by graft tests. (7 minutes).** G. H. RIEMAN, University of Wisconsin, Madison, Wis., and HARI KISHORE, Central Potato Experimental and Trial Center, Babugarh, Hapur, India.

10. **Low temperature storage effects on barrier development and decay of potatoes. (10 minutes).** W. L. SMITH, JR., U. S. Department of Agriculture, Beltsville, Md.

Tuesday Afternoon, August 30, 1960

Symposium on "Potato Processing"

Spurgeon Chapel, 1:30 P.M.

ORA SMITH, Presiding

1. **Potato processing and its future. (20 minutes).** A. E. MERCKER, Executive Director, National Potato Council, Washington, D. C.

2. **Recent research and development of potato chip processing. (20 minutes).** ORA SMITH, Cornell University, Ithaca, N. Y.

3. **Recent research and development of frozen French fries and other frozen potato products. (20 minutes).** IRVIN C. FEUSTEL, Western Regional Research Laboratory, Albany, Cal.

4. **Recent research and development in potato granules. (20 minutes).** CARL HENDEL, Western Regional Research Laboratory, Albany, Cal.

5. **Recent research and development in potato flakes. (20 minutes).** JAMES CORDING JR., Eastern Regional Research Laboratory, Philadelphia, Penn.

6. **Recent research and development in potato flour and potato starch. (20 minutes).** R. H. TREADWAY, Eastern Regional Research Laboratory, Philadelphia, Penn.

7. **Some considerations on processing plant location. (20 minutes).** R. L. SAWYER, Cornell University, Riverhead, L. I., N. Y.

Wednesday Morning, August 31, 1960

Spurgeon Chapel, 8:30 A.M.

Business Meeting

PAUL EASTMAN, President, Presiding

Wednesday Morning, August 31, 1960

Spurgeon Chapel, 10:00 A.M.

CHARLES E. CUNNINGHAM, Presiding

1. **Effect of carbon dioxide on cooking and processing quality of potatoes. (12 minutes).** C. O. DAVIS and ORA SMITH, Cornell University, Ithaca, N. Y.

2. **Preventing discoloration in cooked and French fry potatoes. (15 minutes).** ORA SMITH and C. O. DAVIS, Cornell University, Ithaca, N. Y.

3. **Chip color in relation to potato storage. (15 minutes).** F. J. STEVENSON and C. E. CUNNINGHAM, Red Dot Foods Inc., Madison, Wis.

4. **Potato variety trials. (15 minutes).** F. J. STEVENSON and C. E. CUNNINGHAM, Red Dot Foods Inc., Madison, Wis.

5. **A study of the tuber sizing and accumulation of total solids content of several varieties of potatoes harvested weekly during the growing seasons of 1957-59. (10 minutes).** G. R. JOHNSTON and R. G. ROWBERRY, Ontario Agricultural College, Guelph, Ontario.

6. **Sampling of potato tuber population for dry matter assessment. (5 minutes).** DONALD A. YOUNG, Canada Department of Agriculture, Fredericton, N. B.

7. **Potato composition versus chipping quality. (15 minutes).** E. F. HOOVER and P. A. XANDER, Wise Potato Chip Company, Berwick, Penn.

Wednesday Afternoon, August 31, 1960

Spurgeon Chapel, 1:30 P.M.

O. C. TURNQUIST, Presiding

1. **Mutability of *Phytophthora infestans* on blight-resistant selections of potato and tomato. (15 minutes).** K. M. GRAHAM, W. A. HODGSON and L. A. DIONNE, Canada Department of Agriculture, Fredericton, N. B.

2. **Laboratory testing for intermediate levels of resistance to *Phytophthora infestans*.** (15 minutes). W. A. HODGSON, L. A. DIONNE and K. M. GRAHAM, Canada Department of Agriculture, Fredericton, N. B.

3. **The inheritance of resistance to higher races of *Phytophthora infestans*.** (15 minutes). L. A. DIONNE, K. M. GRAHAM and W. A. HODGSON, Canada Department of Agriculture, Fredericton, N. B.

4. **Incompatibility relationships of haploids from *Solanum tuberosum* subsp. *andigena*.** (12 minutes). M. S. CIPAR, S. J. PELOQUIN and R. W. HOUGAS, U. S. Department of Agriculture and University of Wisconsin, Madison, Wis.

5. **The frequency of haploids in *Solanum tuberosum*.** (12 minutes). S. J. PELOQUIN, R. W. HOUGAS and A. C. GABERT, U. S. Department of Agriculture and University of Wisconsin, Madison, Wis.

6. **Initial evidence concerning the feasibility of potato breeding at the diploid level.** (15 minutes). R. W. HOUGAS and S. J. PELOQUIN, U. S. Department of Agriculture and University of Wisconsin, Madison Wis.

7. **A comparison of first clonal generation potato progeny performance at two Minnesota locations.** (10 minutes). A. W. BLOMQUIST and F. I. LAUER, University of Minnesota, St. Paul, Minn.

8. **A simplified technique for the storage and handling of potato pollen.** (10 minutes). A. W. BLOMQUIST and F. I. LAUER, University of Minnesota, St. Paul, Minn.

9. **Potato genetics: Inheritance of chip color and dry matter content.** (15 minutes). C. E. CUNNINGHAM and F. J. STEVENSON, Red Dot Foods Inc., Madison, Wis.

10. **Estimates of combining ability of potato clones.** (15 minutes). R. L. PLAISTED, LIND SANFORD, W. T. FEDERER, A. E. KEHR, L. C. PETERSON, Cornell University, Iowa State College and U.S.D.A., Beltsville, Md.

11. **Erli-red, a new red-skinned potato variety with high red color, market attractiveness, earliness and easy to grow and handle.** (10 minutes). BEN PICHA, Grand Forks, N. D.

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES TRANSLATION PROGRAM

The American Institute of Biological Sciences is currently translating and publishing seven Russian research journals in biology. These journals are translated with support from the National Science Foundation, which is eager that such information be more widely distributed to biologists throughout the world. It is hoped that this material will aid biologists in research, prevent duplication of work, give some idea of the work being done by Soviet scientists in the field of biology, and also bring about a better international understanding among scientists.

Because of the support of the National Science Foundation, the AIBS can offer these translations at a fraction of their publication costs, with even further price reduction to AIBS members and to academic and non-profit libraries. This reduction, the AIBS feels, places the translation within the reach of all biologists.

The journals currently being translated are: Doklady: Biological Sciences Section; Doklady: Botanical Sciences Section; Doklady: Biochemistry Section; Plant Physiology; Microbiology; Soviet Soil Science; and Entomological Review.

In addition to its program of Russian Biological Journal translations, the AIBS has instituted a separate program of translation and publication of selected Russian monographs in biology.

It was felt that the program of Journal translations was not sufficient to cover all of the significant work being done in all fields of biology by Russian scientists. With the aid of competent authorities, the AIBS has translated and published six Russian monographs and one monograph is in the process of being published. In addition, several prominent monographs in various biological areas are being considered by the AIBS and the National Science Foundation for translation and publication. The monographs that have been published are: Origins of Angiospermous Plants by A. L. Takhtajan; Problems in the Classification of Antagonists of Actinomycetes by G. F. Gauze; Marine Biology, Trudi Institute of Oceanology, Vol. XX, edited by B. N. Nikitin; Arachnoidea by A. A. Zakhvatkin; and Arachnida by B. I. Pomerantzev. The manuscript for Plants and X rays by L. P. Breslavets is in the final stages of preparation and should be published early in 1960.

Additional information pertaining to this program may be obtained by writing to the American Institute of Biological Sciences, 2000 P Street, N. W., Washington 6, D. C., U. S. A.

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